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What's behind the semiconductor shortage and how long could it last?
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This transcript has been lightly edited.

DOLLAR: Hi, I'm David Dollar, host of the Brookings trade podcast Dollar and Sense. Today, we are talking about the semiconductor shortage which has caught the world off guard and is disrupting the auto industry and other sectors of the economy. My guest is Don Clark, a contributor to The New York Times on technology issues. Welcome to the show, Don.

CLARK: Hello there.

DOLLAR: So let's start with the big picture. How serious is the semiconductor shortage for the economy now that we are recovering from the pandemic recession? What are the sectors that are particularly hurt by this?

CLARK: Well, I think the reason we are here talking today is because of the impact on the auto industry, which is a huge sector of the economy. They have been forced to temporarily close a bunch of plants in North America because of the chip shortage. So that has caused alarm bells in particular. Those are union jobs, the kind of people that voted for President Biden. This has definitely got the world's attention, but there's many other sectors of the economy that are affected. And not that the economy is doing that badly, but it's kind of like we would be in a much better position had this not happened.

DOLLAR: I've read a number of your articles. You have some great stories about the types of firms that are affected far away from automobiles. You had one about a cement manufacturer. Does that ring a bell?

CLARK: This is a company that makes a little sensor that you place in places where you are going to pour concrete. So with these things that measure temperature in the ground, they beam signals to some people with laptops nearby and they can tell how quickly cement is hardening so that it's secure. So these guys are worried about making future sensors. And they are worried not just about themselves, but on all the construction projects that they are involved with.

DOLLAR: So we've got chips just throughout the economy now. It's really an interesting change. So how did we get to this shortage? What's the failure here? We economists usually think about there being some kind of market failure to get you into a real mess. So, what was the failure here?

CLARK: Well, it's really a combination of short-term and long-term factors both on the supply side and on the demand side. So the short-term factor, of course, is the pandemic. When the pandemic came around, people pulled in their sales or they just physically couldn't keep production going. So the automakers in particular shut down temporarily. Meanwhile, everybody else, after sitting around at home, started buying everything you can imagine, particularly computers, appliances or game consoles, tablets, everything to educate and entertain themselves at home. So they started placing orders, and when the car guys came back around in the September time frame, they basically had lost their place in the manufacturing

queue to get chip supplies. So they were disproportionately hurt. But there's some other really interesting factors.

The chip industry has had many shortages before, but they usually are in a particular kind of chip like memory chips. This time it's across the board, which is a sign that demand is really going through the roof. There's two vectors. The chips are being used in many more kinds of products, and then each product that is using chips—like a car or a smartphone—they are using many more chips. So the cars that we are making today, they were designed three years ago. The cars next year are going to have even more chips. So it's this kind of treadmill that wasn't really factored in.

The other thing to keep in mind is that there's both the new cutting-edge chips that are scarce supply—those mainly come from this one company, TSMC, in Taiwan, and that's what's in, say, the latest Apple smartphone—but also all these old factories, old chips, very simple things that factories that were paid off years ago. In those cases, it's very hard to upgrade those supply lines. The biggest factor is demand, but after that you get to these supply bottlenecks.

DOLLAR: Right. So to some extent, it sounds like the chip manufacturers didn't anticipate this big surge in demand, which is kind of understandable because it's been a really uncertain world.

CLARK: Yeah, and they have been expanding, but the great thing for a chip manufacturer is when their factory is full. They love that. When it's empty, they lose lots of money. But if there's a shortage and they can't fill demand, they sort of leave money on the table. The history of the chip industry has been marked by these periods where they built too many factories so there's a glut of chips or they built too few factories and there's a shortage of chips. So they weren't getting accurate demand signals from their customers. So a lot of the problem here is properly evaluating and forecasting demand, which is very difficult.

DOLLAR: Then I take it these firms cannot easily ramp up production. So the firms that suddenly have large increases in demand, can't just—

CLARK: Yes, they cannot. And there's two dimensions of that. If they just wanted to build a new factory from scratch, the cutting-edge factories are $10 billion a pop, takes three years to build them. So that's a long lag right there. Then you have these older factories I was talking about. Some of those are using a kind of smaller silicon wafer to make the chips, and the machines for making those kinds of chips aren't being made anymore. So they can't increase production even if they want to. So anyway, it's not an easy situation.

DOLLAR: Right. So that's a pretty convincing story about the main factors that got us into this semiconductor shortage. But I've read some other interesting theories—and maybe they are just kind of random asides. One is that the explosion of interest in Bitcoin and crypto currencies more generally is affecting semiconductor demand. I guess semiconductors are used in the mining operation to create these things.

CLARK: Yes, that's true. I mean, it's at the margin, but it's a factor to some degree. So this company called Nvidia, which has been one of the most successful chip companies in the past five years, their chips are used in video game consoles and in gaming PCs but it turns out that they can also do the kind of math that is involved in Bitcoin mining. So there have been times in the past few years where the Bitcoin miners bought up all the graphics cards that use these chips that they could. So that's been a factor. That's not a huge thing, but for a company whose products are already incredibly popular, having this additional source of demand. Nvidia has gone so far as to make new tweaks to its chips to prevent their use in Bitcoin mining, which I'm not sure how successful that's being, but it is a factor.

DOLLAR: And I'm guessing there's probably a similar story around the big freeze we had in Texas, because the U.S. industry, I gather, the U.S. production of chips is very much concentrated in Texas and some factories were shut down because of the deep freeze. Did that contribute?

CLARK: Well, NXP, which is a company that was combined of the old Motorola operations from years ago, they have older factories in Texas and they do supply the auto industry. So those were shut down temporarily and they had two factories temporarily closed. And Samsung has a sizable factory in Austin that was also closed. But, despite the shutdown, NXP's revenues rose 27 percent in the first quarter. So they have other factories around the world and demand is just going through the roof. So, it is a factor.

There was also a fire at Renesas, a Japanese auto chip supplier in Japan. That was another factor, but these are not the factor. It's kind of like a perfect storm of issues.

DOLLAR: Right, it's what we call overdetermined. You've got a main explanation and then these other things just make things a little bit worse. They probably get disproportionate attention because we are already worried about a chip shortage. So a factory goes offline, and it gets some attention, but those are not the main stories.

CLARK: Right.

DOLLAR: In the same vein, I'm curious about the U.S.-China trade war. Semiconductors play an important role. The U.S. is not selling them to Huawei. That used to be the largest Chinese smartphone manufacturer. It's not anymore; it's been displaced by another Chinese firm, Xiaomi. I think there are at least two Chinese firms that have gotten out ahead of Huawei now. But just intuitively, you would think if the U.S. is not selling semiconductors to China, if anything that should be creating a glut on our side of the Pacific. But did this somehow backfire on us?

CLARK: No, I wouldn't say it backfired, but I would say it didn't operate in the way you might have expected it to operate. One thing is that Huawei—and there were some other Chinese companies affected by the sanctions—they started stockpiling chips. They saw this coming, so they used every trick they could to stockpile as many chips as they could. That contributed at certain points to the supply crunch. Then, in the case of Huawei, when they stopped being able

to sell smartphones these other Chinese companies' total smartphone sales did not go down. Just their sales went down. Other companies came in to fill the void, so it was a net neutral on demand for chips.

DOLLAR: Right. Except those other companies are stockpiling now because they are worried that they might be sanctioned by the United States in the future.

CLARK: Exactly. You know, I don't think the policy really had that much impact on the actual shortage. But during the pandemic, when we had shortages of like personal protective equipment and things like that, basically the psychology about—wait a minute, we have a fragile supply chain, America generally shouldn't be dependent on all these foreign sources of things. So it didn't actually affect the shortage in my opinion, but it made everybody kind of worried. So, like Taiwan is right next to China, what if someday China decided to retaliate or something and attack Taiwan? We would really be in a pickle.

DOLLAR: Turning to potential solutions. This kind of shortage gets a lot of attention. As you say, it's putting some auto workers out of work; it's affecting other sectors. Of course, there's quite a bit of noise coming from politicians of both political parties, but is there much the government can do? What would you recommend the U.S. government do to kind of address this—

CLARK: What's interesting, there was a whole "Build America" manufacturing of chips that preceded any of this shortage thing—that was proceeding. And then the shortage hit, so Biden came in and he issued this 100-day supply chain review and everybody got sort of over-exercised. But the two things kind of overlay on each other. I mean, for example, the Pentagon has always worried about foreign chips, and these kinds of things have been going on and we worry about China as a manufacturing rival. So there's many dimensions to it. But none of the proposals being floated really have a short-term benefit to easing the shortage. All the things that are going to happen there is the short-term issues are better planning, better forecasting, prioritizing of the manufacturers—which chips they decide to make first because they keep certain plants, car factories, operating. So really, it's industry that's going to solve the short-term issues.

Long term, there are things the government can do, and we can talk about that. But really, there isn't much in the way of a short-term fix that the government has any control over.

DOLLAR: Right. I think our main theme of our podcast is international trade, but we interpret that very broadly because there's so many topical interests. But one instinct that you're certainly find in the U.S. is that somehow trade is part of the problem here; that if we weren't so dependent on imports that that would be a different situation. I'm pretty skeptical about that argument.

Semiconductors, it's an interesting product where it happens that our trade balance is pretty much zero. I mean, it's pretty much balanced in semiconductors. We export about $55 billion of

semiconductors; we import about $55 billion. You can probably help us understand that. I'm assuming what we export and what we import is not the same.

CLARK: Yeah, most of what we export are the Intel microprocessor chips. They have always kept a strong manufacturing presence. But broadly speaking manufacturing, we make like 12 to 13 percent of what we consume, which is down from around 30 percent. But the thing about this industry, it is more globally interdependent than any industry in the world. You get rare earths from someplace in Africa for the minerals or China or wherever you get all these machines that are made in various places. The Dutch company ASML is the world's only supplier of the machine that is pivotal to making the most advanced chips. Basically, there's all kinds of interdependencies. When a chip is made, once you get it manufactured, it can cross borders 70 times before it gets to the final. So, this idea that we can snap our fingers and make the U.S. independent or self-sufficient, that's nonsense.

We can reduce the dependence, particularly on certain kinds of chips for defense, national security, certain things. There are already these things called trusted foundries, which the Pentagon has for years made some very special top-secret chips in. They won't let a foreign national work in these factories. But those trusted foundries are way behind the state of the art. So part of this in the background that's been going on is to make those much closer to the state of the art. There's a company called GlobalFoundries, which is in upstate New York. It took over the old IBM fabs. So they are kind of like the key, but they are owned by the government of Abu Dhabi just to make it confusing. Self-sufficiency is a goal we will never achieve. But reducing our reliance, particularly for certain products, is achievable.

DOLLAR: Right. It makes sense to focus that on the items that are truly of national security importance. So presumably our military hardware, we want to have that produced in the United States and all the inputs as much as possible. And I think we already do to a large extent, but it's worth looking into that because these value chains are so complex now. There might be some part of that that's not well understood. So I think that makes sense.

CLARK: There's a kind of a chip called an FPGA, field-programmable gate array, which is the chip that can be basically tailored for its application after it leaves the factory. While the top-secret custom chips are designed in these trusted foundries, TSMC in Taiwan has become a huge supplier for these FPGAs, which the military heavily depends on for like the F-22 fighter jet and things like that. So TSMC has now announced the plan under the Trump administration's cracking the whip to make a $12 billion factory in Arizona. So that would be nice from the Pentagon standpoint to have a domestic source of some chips like that. Apple, for instance, [which is] TSMC s biggest customer, would love to have more of that production in America.

DOLLAR: So is that TSMC plant actually going ahead? Is that your impression?

CLARK: They have said they will require subsidies. So turning to this act, it keeps changing its name and it keeps moving around from the various Biden packages. Right now, it's up to $52 billion as a package, and basically the chip guys say: I just want the same subsidies that Taiwan

is giving me, that South Korea is giving me, that Israel is giving me, countries like that. Taiwan has said we are really not going to build this factory unless you give us some subsidies. Intel has announced a $20 billion expansion and they have sort of said we are going to build this anyway, but I think they definitely want them too. It's almost like they want to be able to say to their shareholders, we are not giving the U.S. something that all these other countries are not giving us. So it's kind of a—of a $20 billion factory, you might be talking a billion dollars in subsidies. So the government's not buying them these factories, but they are giving them incentives.

DOLLAR: So looking longer term, you already referred to this to some extent, the Biden administration and actually both our political parties talk about bringing back more production in the United States. Reshoring, rebuilding manufacturing to some extent, and definitely in the semiconductor area but connecting it to other different sectors. So, is this realistic? What do you think about this, and what would be the main policies you would recommend to try to get a sensible outcome in this area?

CLARK: Well, as I said, I think it is an achievable goal to go from, say, possibly 12 percent to possibly someday maybe 30 percent of our semiconductor needs in this country. That will take a lot of effort, and I think that is achievable. Besides the raw manufacturing, there's endless amounts of research and development that go on. Really, the battle is not over today's chips, it's over tomorrow's chips, and trying to stay ahead of China in that kind of field is important for various reasons for people who worry about this.

It's an interesting time because this is one of few areas Republicans and Democrats agree on. They have consistently voted for this thing. It's really now just a matter of getting it in the right part of the administration's packages that doesn't carry too much baggage that the Republicans won't go along with. So, I really think that something will happen here.

One of the interesting dimensions in this debate that Biden administration triggered over the supply chain is the auto industry said we want special earmarked stuff for just us. Every other industry said, no, no, no, we just have to get the chip industry generally working. But this latest package went [from] $50 to $52 billion dollars to put in $2 billion for sort of auto industry-specific stuff, which I'm not quite sure how that would actually even work, but that's what's in there. So I do think it is achievable to boost American competitiveness.

One of the dimensions we haven't talked about is that once the chip gets fabbed on the semiconductor wafer, it is sent to another country, usually, to be encapsulated in plastic and tested before it can be put into a system. That assembly and industry is even less in America than the fabs. One of the overlooked dimensions of this is to try to rebuild some sort of packaging industry in America. And that's a tall order, but that's part of this whole package.

DOLLAR: It seems to me we've got two somewhat confused objectives. So there's the national security technology-edge objective, and I think that's realistic for the United States—the kind of money you are talking about, $50 billion—that can make a difference in terms of R&D, certain production, semiconductors. But then there's this more general protectionist sentiment in the

U.S.: we should be bringing all this production back. I think that's not realistic and that's actually going to be very expensive. So I do worry that if we get a couple of years down the road, and I don't think we're going to make much progress on that second agenda, we get a couple of years down the road and people realize that there are a lot of reasons why manufacturing jobs are declining as a share of the labor force, and it's extremely unlikely we are going to reverse that. So I personally prefer to focus in on that national security technology concern and generally I resist the protectionist instincts.

CLARK: Yeah, and I think that's why you got Republicans to sign onboard as they agree with you in that respect. That is the part that they are most interested in. And the anti-China sentiment does factor into this quite strongly. The chip industry produces jobs, but these modern semiconductor plants, they are the most complex creations man has ever built. They might require a couple of thousand people, but it's very automated. The people in there are very highly educated. You can't even run one of these factory tools in there unless you have at least a two-year college degree. It's not a blue-collar job kind of thing except, say, in the construction of a new factory or some of these things. It is an important industry and it should be here in the U.S., but like I say, we are never going to dominate world production like some people might want.

DOLLAR: There's a joke in China that the factory of the future has one worker and one dog. The dog is to make sure that nobody touches the machines and the worker is to feed the dog.

CLARK: Yeah, I think there's something to be said for that. For example, I mean, China has always had this policy. If you want to sell in China, you've got to put your factory in China. America didn't do that when, say, solar panels came around. We just let everybody flood the market with their solar panels, you know. So we never embodied any of those kinds of policies that many other governments around the world require—not just China.

DOLLAR: But, Don, you are saying that we are seeing quite a few governments subsidizing semiconductors and the U.S. is now getting into this business. The last question I want to ask you is just to kind of look ahead a little bit. On the one hand, how long are we likely to have this shortage? Then the other question is, are we likely to see a glut following this shortage? Are we going to get too much investment, too much production, [and] are we going to look back in a few years and have a glut in this industry?

CLARK: Well, I'll take the second one first. It has always happened in the past that we have had a glut after one of these shortages, but that's because we were really concentrated on these particular things, particular segments of the semiconductor industry, like memory chips. Basically a fungible commodity that just changes based on pricing. So we are in a long-term phase of demand growth here. Basically, products are not going to start getting dumber all of a sudden. Products are all going to keep getting smarter; they are all going to need chips. I'm not saying there could not be a glut situation, but based on the companies that are making these commitments to build, they are not like ridiculous expansion. I mean, they are basically pretty

sensible projections based on demand for the products they see. So I don't see a big problem in that respect.

Getting to your first question, the shortage is going to be with us, most people say, to at least mid-2022. And it's really a lot of that just comes down to really the basic blocking-tackling of the industry. You know, getting more output out of each tool, recycling your materials. You have to keep in mind one of the reasons the auto industry got screwed is because they adopted this just-in-time manufacturing strategy. So to maximize their cash flow, don't deliver those components until just when I need them. And this is really been seen to be a big problem.

The one company that did better in the shortage is Toyota. They say the reason is because of the earthquake tsunami issue in Japan some time back—they realized we better have a stockpile of things, so they have more of a stockpile in the U.S. of components. And the whole auto industry, the customers have got to get smarter as well as the manufacturers. They have to build in resilience into their own manufacturing.

DOLLAR: I'm David Dollar and I've been talking to Don Clark about the semiconductor shortage and related technology and trade issues. Thank you very much for joining us today.

CLARK: Thanks for having me.

DOLLAR: Thank you all for listening. We'll be releasing new episodes of Dollar and Sense every other week, so if you haven't already, follow us wherever you get your podcasts and stay tuned.

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